Principles of

Production Planning

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PRINCIPLES OF PRODUCTION PLANNING

In the medical profession, the advent of wonder drugs has given the doctor powerful new techniques; but, ironically, his job has become more complex and his responsibilities more awesome. He can accomplish startling results with these new tools when he applies them properly, but they can also be very dangerous if misused. In the field of production and inventory control, we face the same situation. There are powerful new tools at our disposal and many techniques like scientific inventory control, machine loading, and centralized dispatching that were well known but not applied very often that can be implemented practically now that computers are becoming widely available in manufacturing. But we must learn more about our field if we are going to use these techniques wisely and obtain real results. Unlike the doctor who is dealing with the human being whose design has remained pretty much the same for some time, our businessess generally have become far more complex in recent years forcing us to look to new techniques with a great sense of urgency. My concern is that we may be so conscious of our need to cure some of our ills that we may misapply the techniques and that the "patient" may improve only temporarily or even suffer a setback.

Observation of many companies has led me to conclude that one of the weakest areas of manufacturing control is that of production planning, and the symptoms of problems in this area can be particularly deceiving. Seven common symptoms of serious deficiencies in production planning are:

1. "We are always behind schedule . . ."
2. "It's <u>their</u> job to meet the schedule . . ."
3. "We need more lead time . . ."
4. "We need more space . . ."
5. "We never make work for the plant . . ."
6. "We insist that the plant work to the date on the order . . ."
7. ". . . Unless the job is 'rush,' 'super rush,' or 'red sticker' . . ."

In discussing the real problems indicated by these symptoms, I will try to point out:

1. Why traditional approaches to shop loading practically force many plants to operate behind schedule and how better production planning techniques can enable a plant to operate efficiently with <u>less</u> lead time and <u>less</u> space.

2. Why a system that never releases work to the plant ahead of schedule often generates large levels of work-in-process and how these can be lowered.

3. Why most companies would be better off if they put no dates on shop paper as part of their detailed planning and how a more satisfactory method for handling job sequencing in the shop can be used.

Let's start out with a definition of "production planning" since this is the major area we are probing. The original APICS Dictionary defined it as: "The function of setting the limits or levels of manufacturing operations in the future, consideration being given to sales forecasts and the requirements and availability of men, machines, materials and money."

The inventory control system, the dispatching system, and even the machine loading system are not likely to function very well if production planning is not done properly. This may seem contradictory at first since machine loading is one of the best known production planning techniques but Figure 1 shows how a machine load looks in most companies. Note that this week and next are badly overloaded while the load is down closer to capacity in Week #3 and then it starts to taper off. The foreman's reaction to this information is usually less than startling; he certainly doesn't have any real basis for adding manpower since it will take a minimum of three to four weeks to hire a man and then he would like to keep him for some period of time before laying him off. An effective "manpower plan" should extend far enough out to show capacity requirements over a period far enough in advance to cover hiring time plus minimum employee retention time. Most companies have not established a policy regarding a minimum period of time for which they will provide work for a man once he has been hired; a few have, and the figure I hear most often is eight weeks. This means that the load report -- by itself -- will not usually be an adequate manpower planning tool unless backlogs of orders are available to extend the load out at least ten or twelve weeks into the future. When the load report does not extend out this far, it can provide good information for the "short strokes" of the game -- overtime, switching men from one machine to another, etc. -- but it doesn't succeed in getting the ball out on the fairway. Since one of his prime objectives is to operate at a steady rate, the foreman sees real security in backlogs and his reaction to an increasing load is to run behind schedule until very large backlogs have generated extreme pressures to add manpower.

Before pursuing the problem any further, let's look at the subject of "lead time." The actual manufacturing lead time is made up of Set-up

Time, Running Time, Move Time and Queue Time -- the time a job spends waiting to be worked on. This queue time is a function of the size of the backlog and as it goes up, lead time increases. Unfortunately, the reaction of most companies as lead time increases is to plan on longer lead times in their inventory systems which will then generate more orders which will in turn increase the backlogs and push the lead times up even more! I'm amazed at the number of supposedly sophisticated systems that try to build a reaction to longer lead times into the inventory control system ignoring the real problem which is usually lack of capacity.

Planning manpower requirements far enough in advance to give the foreman enough notice so that he can actually effect a change in manpower poses a real dilemma since most companies today are trying to operate with smaller and smaller backlogs while pressures from the government and unions are forcing them to try to keep employment levels more stable. If large enough backlogs are maintained in the machine load report to be able to effect a change in manpower, lead times will tend to be extremely long and these long lead times will compound the problems of sequencing orders in the plant since for most companies the determination of required dates on orders is based on some kind of a forecast, and forecasts tend to get very poor as they are extended farther out in time. Thus, the longer lead times generated by larger backlogs of orders make the dates that are originally placed on the orders less and less valid means for sequencing orders.

The solution to this apparent dilemma is to recognize forecast characteristics in production planning. There are two basic characteristics of forecasts that apply:

1. Forecasts are more accurate for shorter periods of time.

2. Forecasts are more accurate for larger groups.

We can then conclude that a manpower forecast which must be extended out over a fairly long period of time should be for the largest possible group that is meaningful in terms of plant capacity requirements and that individual order requirement dates should be forecast over the shortest lead time possible. This implies that the manpower forecast should be made in terms of groups of products without generating actual orders.

I have found this approach applicable in practically every plant where large backlogs of orders cannot be tolerated. Let me give you some specific examples. Figure 2 shows a quarterly production plan made for a group of products that are produced to maintain a finished goods inventory. There are approximately 100 products included here, and the production plan is expressed in pieces. Currently, there is an actual inventory of 150,000 pieces on hand; at the end of the 13-week planning period, it is desired to have this inventory increase to 280,000 pieces to cover anticipated seasonal increase in sales plus a plant shut-down period. The sales forecast for this product groups calls for selling 30,000 units per week; and in order to attain this inventory increase, it will be necessary to feed 40,000 units per week into production. Once this type of plan has been made, it serves somewhat like a "budget"; the actual inventory levels can now be compared with the planned levels, the sales with the forecast, and actual production can be monitored against the planned production rate. This is a very simple production plan where the entire product group draws upon common manufacturing facilities, and the plan is expressed in "pieces" which happens to be meaningful as a measure of manpower requirements in this case.

Figure 3 shows a production plan for a group of components that are used to make an assembled product. These components are manufactured in a machining department, and the objective of this production plan is to develop a gross projection of the total number of machining hours that will be required as a means of controlling the backlog and thus controlling overall lead time. Note that the inventory is now expressed in terms of machining hours; the orders which represent anticipated withdrawals from the component stockroom for the assembly line are also expressed in terms of machining hours, and the 12 week production plan calls for 4300 hours of production in order to increase the component inventories anticipating an increase in the assembly rate in the third quarter of the year.

Figure 4 shows a machine load projection that has been made on a computer using the regular machine load program to make a periodic projection of requirements as a means for setting the production level. Note that from this "simulation" of requirements, it can be seen that in Week 45, the actual orders that the system will generate will probably be far less than the 120 hours of capacity normally available on the first shift, while by Week 48, capacity requirements will run over into the third shift. As with the other production plans shown, this projection is made without generating actual orders. The objective is to plan capacity requirements far enough in advance so that manpower levels can be changed without having to wait for large backlogs to develop.

Figure 4 also indicates another major problem area. If the inventory system is merely allowed to generate work at random, it will be necessary to run considerably behind schedule in order to keep people working at a steady rate. Most inventory systems generate lumps of work to the plant, and the foreman's reaction to these lumps is to stabilize production by running behind schedule. In an article appearing in the APICS Quarterly Bulletin, October 1965, titled, "Routing, Scheduling and Dispatching the Job," Robert Collins of Automatic Electric Company observed, "When you have planned capacity, you have the responsibility to provide sufficient work to sustain it," and one of the ironies in production control is that work-in-process can be maintained at a lower level when the input of jobs to the plant is regulated to meet the planned production rate rather than when it is released strictly based on dates established by the inventory control system. Let me give you some examples of techniques for controlling input. Figure 5 shows a stock status report that is designed to be used in conjunction with a production plan. Here, the inventory is reviewed weekly as part of the system; and since inventory is currently being built ahead of plant shutdown period, most items are above the order point. The scheduler has a problem looking at the inventory for each item and the order point for each item and determining which item should be put into production to meet the planned production rate. By constructing a "critical ratio" which expresses the relationship of the total inventory to the order point, the scheduler can quickly review this stock status report and determine which items to put into the production schedule first. In Figure 5, Item #9 is below order point and obviously should go on the schedule. Item #7 has the next lowest critical ratio and should be put into production next followed by Item #5, etc.

Perhaps a specific example illustrating how regulating the input of work to the plant and starting some orders before the inventory system indicates they should be started will clarify the concept. In one company, a large screw machine department normally operated with 13 or more weeks of backlogs; the inventory control system recognized that the lead times were 13 weeks and generated orders at random 13 weeks ahead of the dates when it was believed they would be required. The reason for the 13-week lead time in a screw machine department, where it obviously takes far less time to produce the product, was that the foreman maintained large backlogs as a means of stabilizing the production rate since he was far more conscious than the production control people of the need to keep skilled machine operators working at a stable rate. In order to give him a better means for planning, a forecast of anticipated requirements <u>by machine group</u> was made indicating the total number of hours of work that would normally be required for each machine group. At the same time, the inventory system was revised to show that screw machine lead times were 4 weeks instead of 13 weeks, and a great many orders were cancelled. Then the inventory status for each screw machine part was reviewed weekly, and orders were chosen to be fed into production to meet the production rate that had been planned previously. Of course, these orders sometimes had to be started ahead of the date that the inventory system showed, but since the inventory system now reflected a 4-week lead time rather than a 13-week lead time, ironically, starting some orders <u>ahead</u> of the date now indicated by the inventory system enabled the flow of work into the plant to be levelled, backlogs to be lowered, and overall lead times to be reduced dramatically. As a by-product, the sequencing of orders was much improved since the inventory system was far better able to predict actual order requirements four weeks in advance than it had been able to do when it was necessary to project these requirements out 13 weeks in advance.

These approaches are being used in a good many companies today as a means to controlling lead times and job sequencing. Unfortunately, there are no universal techniques that can be used to apply these principles and the challenge lies with the production control man to identify meaningful product groups and get his forecasts in these terms and then develop an inventory system that is responsive and gives him up-to-date requirements for individual orders. This is a far more workable approach than trying to reflect increasing lead times in an inventory system and trying to project individual order requirement dates over increasingly longer lead times. The relationship is easiest to see in a company where the inventory system generates orders for the plant; but, of course, practically every company is manufacturing against orders generated by <u>somebody's</u> inventory system. When a supplier, for example, starts quoting longer lead times, his customers normally start ordering farther ahead; and the result is typically to generate an increase in the supplier's backlog which will in turn generate a further increase in his quoted lead times. In the meantime, the ability to predict the sequence in which the orders are needed degenerates rapidly and expediting becomes a way of life.

While we're on the subject of expediting, let's look at the function an expediter has in many plants. The expediter working from "short" lists, "Past-due" lists, and "backorder" lists tries to "rush" particular orders through the plant. When a foreman is confronted with the expediter's "hot list" and asks what he's supposed to do with the regular schedule, the expediter usually replies, "Try to work that in too!" The problem with the expediter is that he gets his information concerning orders where requirements have <u>increased</u> in one way or another, and he never seems to find out about orders for which requirements have <u>decreased</u>. I feel that a real contribution to the efficiency of most plants could be made if they added a new job classification called the "unexpediter." This man would be responsible for finding out which jobs could be put at the end of the queue to complement the expediter who is always trying to put jobs at the head of the queue. A solution to this problem of job sequencing exists today in the form of the "Critical Ratio" technique which was developed by Arnold O. Putnam of Rath & Strong. This technique periodically calculates a ratio of the inventory to the order point and a ratio of the current work remaining on a job to the originally planned lead time and combines them into a simple priority number. Using this type of approach, the jobs in a plant can be re-sequenced frequently so that the job selection ahead of any machine center is based on latest requirements rather than some requirements that were established at the time the order was originally started. The Critical Ratio approach can also be used where a requirements planning system or a customer provides an order "due date." This due date can be recalculated by the inventory system or as the customer changes it; it can be used to recalculate a new Critical Ratio that will indicate the proper sequence in which to run the jobs in the plant based on the latest requirements. The Critical Ratio technique is being covered by Arnold Putnam in a separate talk at this conference. I think that it represents a major contribution to a more responsive production control system.

Let me try to sum up some of the concepts presented here by stating three major principles that I believe have wide application:

1. Manpower requirements should be forecast for groups of products without generating actual orders.

2. The production plan should be used to plan and control capacity and to regulate the rate at which work is fed into the plant.

3. Shop priorities should be recalculated frequently based on the latest requirements and relative job progress.

Of course, there are other areas of production control in addition to the production planning and order sequencing, and these must be tied in to have an effective system. An inventory control system must be able to generate realistic requirements. This means rational reordering techniques and frequent recalculation of requirements based on latest information. Scheduling and loading are still valid techniques; the schedule establishes the milestones for keeping up with job progress. A scheduling system is fundamental to the use of a technique like Critical Ratio; and, of course, the schedule shows when work needs to be accomplished and is thus basic to the machine load system. The machine load system may no longer be useful as a capacity planning technique for many companies, but it is useful for showing where the temporary overloads have occurred, where the manpower should be moved from one machine center to another, and where overtime can be used most effectively. Incidentally, I believe that when we start thinking of machine load reports in their proper perspective, we're going to see a lot more machine load reports generated as of Thursday morning so that they can be used to schedule week-end overtime, etc., rather than having them produced on Monday morning as they traditionally have been. Another area of production control that needs to be considered is dispatching. As long as there is some choice of jobs out on the plant floor, a dispatcher can provide a valuable service by assuring that these jobs are sequenced properly. He can also relieve the foreman of a good deal of the planning and coordinating of tooling, set-ups, materials and the like.

Having explored the area of production planning in some depth, let's take a look at our seven symptoms once again and see if we are now better able to pinpoint the actual disease:

1. "WE ARE ALWAYS BEHIND SCHEDULE" -- and we are always likely to be if we have a system that does not show the foreman that capacity requirements are increasing far enough in advance for him to do anything about it.

2. "IT'S THEIR JOB TO MEET THE SCHEDULE" -- but it's our job to tell them in general terms what capacity requirements will be so that they will be able to meet the schedule.

3. "WE NEED MORE LEAD TIME" -- lead time is largely a function of backlog, and backlog can only be controlled by having capacity when it is required. Increasing the planned lead times inevitably increases the number of orders generated and, in turn, increases the backlogs thus generating another increase in actual lead times.

4. "WE NEED MORE SPACE" -- yet company after company with poor production planning has found that when they increase the amount of space they have in the plant, the work-in-process tends to expand to fill the space available thus increasing lead times once again. If space is always tight, it may be that the size of the plant is the major control that exists on the level of backlogs that is maintained.

5. "WE NEVER MAKE WORK FOR THE PLANT" -- yet in most companies the level of work must be stabilized. If the foreman has to do this himself, he'll do it with the only tools he has at his disposal; he will run behind schedule and maintain large backlogs. It's far better to feed orders into the plant at a steady rate, occasionally starting an order early based on a very short lead time rather than never starting any orders before the inventory system says they are required based on very long lead times.

6. "WE INSIST THAT THE PLANT WORK TO THE DATE ON THE ORDER" -- yet in most plants, that date doesn't mean very much after the order has been down in the plant for any

period of time. It's far better to have no dates on the orders and to recalculate the priorities and issue these to the plant on a daily schedule or dispatch list.

7. "... UNLESS THE JOB IS 'RUSH,' 'SUPER RUSH,' OR 'RED STICKER'" -- and you can depend on the fact that as backlogs increase, more jobs will need to be expedited and that pretending that the original date on the order is always going to be valid while that order is in the plant will place the burden on the expediters for getting jobs through in the correct sequence.

In his book, Production Planning and Inventory Control,* John F. Magee says, "Production planning is the job of setting the limits or levels of manufacturing operations in the future," and later on, "Production planning sets the framework within which detailed schedules and inventory control schemes must operate." I feel that production planning is one of the most critical areas of production and inventory control. When it is done well, the balance of the system can function effectively; when it is not done well, no amount of sophisticated machine loading, requirements planning, statistical order points and modern dispatching systems will really be able to keep lead times under control and generate consistently good results. It's not at all uncommon for a new system to generate good results temporarily. If you think about it, it stands to reason that after a new system has been installed, the odds are 50-50 that the general situation will either get better or worse. I'm afraid that too often today people install part of a system and then when things seem to get better, they attribute the results to the system because they don't understand how the elements of a system fit together properly and how to properly diagnose production control symptoms.

I had the good fortune to work on the recent APICS FACTORY Survey, and one of the areas that the respondents indicated could be improved significantly was forecasts. Now I will be the first to admit that most companies could do a better job of forecasting, but there is a point of diminishing return that is rapidly reached in improving forecasts, and I wonder if many practitioners are not looking at the problems they have, getting the right jobs through production, and instead of recognizing where the real problem lies, identifying the problem with the symptom.

We have a lot of new and powerful techniques -- the wonder drugs of production and inventory control -- available to us today. But it is our responsibility to be able to diagnose our own problems, recognize the real ills and apply these tools properly with a thorough understanding of principles in order to come up with permanent cures for production planning and control problems.

* McGraw-Hill, 1958, pp. 133.

TYPICAL MACHINE LOAD PATTERN

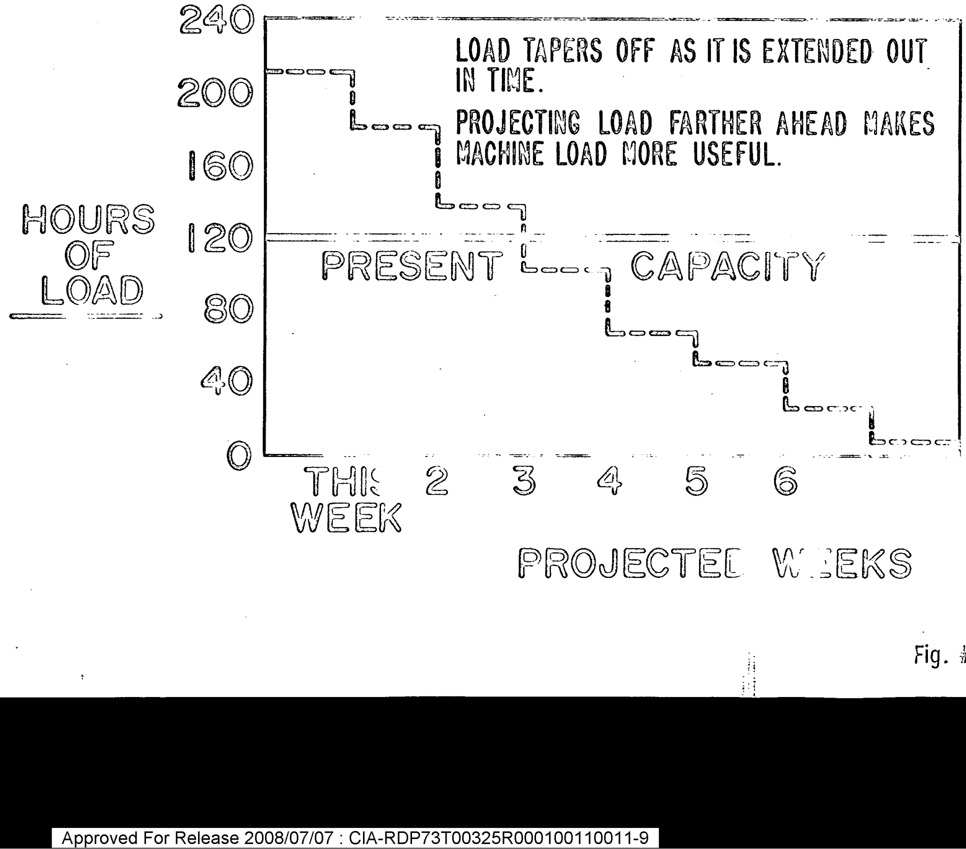

Fig. #1

QUARTERLY PRODUCTION PLAN

WEEK ENDING	TOTAL SALES	PROD.	FIN. GOODS INVENT.
3/31			150
4/7	30 25	40 41	160 166
4/14	30 38	40 37	170 165
6/30	30	40	280

FORECAST

ACTUAL

Fig. #2

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PRODUCTION PLAN IN TERMS OF MACHINING HOURS

WEEK ENDING	TOTAL ORDERS	PROD.	COMPONENT STOCKROOM INVENTORIES
4/7	2800	4300	12820
4/14	2800	4300	14320
4/21	2800	4300	15820
6/30	2800	4300	30820

Fig. #3

MACHINE LOAD PROJECTION

Fig. #4

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STOCK STATUS REPORT

ITEM	TOTAL INVENT	ORDER POINT	C.R.	E.O.Q.
1	4817	2730	1.77	1500
2	2056	1436	1.43	2500
3	5963	4242	1.41	1000
4	2851	1386	2.06	2700
5	8771	6250	1.40	500
6	9894	6768	1.46	2250
7	4080	3346	1.22	1000
8	1781	866	2.06	2500
9	192	239	.80	500

Fig. #5

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